4.—Jointing Associated With The Hampton Fault Near Madura, W.A.

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Jointing exposed in, and controlling the shape of, a cave about six miles south of the Hampton Escarpment is shown to be consistent with downwarping to the south. Evidence for the scarp being produced by normal faulting is reviewed and it is suggested that the jointing is associated with and pre-dates such faulting.

Introduction

The Eucla Basin, of flat-lying Cretaceous and Tertiary sediments, occupies an area of over 40,000 square miles in the south-east of Western Australia and a smaller area in South Australia. It may be divided into two physiographic regions separated by its only prominent feature, the Hampton Escarpment. These are a northern region, the Nullarbor Plain which is a plateau rising slightly to the north, and a southern, the Eyre Coastal Plain.

Stratigraphy

Fairbridge (1953) correlating bore logs has suggested the following sequence:

Formation	*Thickness at Madura*
Eucla Limestone	930 ft.
Hampton Conglomerate	24 ft.
Disconformity	
Madura Shale	over 1100 ft.
Loongana Conglomerate	?
Unconformity	
Precambrian Complex	

The Madura Shale is Cretaceous, diagnostic macrofossils (Teichert, 1947) and microfossils (Raggatt, 1954) having been found in shales of this formation at Loongana and Cook, respectively. The microfossils at Cook are well-preserved Lower Cretaceous foraminifera identical with those found throughout the Great Artesian Basin (Crespin, 1955).

Singleton (1954) has divided the Eucla Limestone into two formations, an upper hard limestone up to 100 ft. thick, the Nullarbor Limestone, and a lower chalky limestone rich in sponge spicules and exposed up to 240 ft., the Wilson Bluff Limestone (presumably named after Wilson Bluff about 20 miles east of Eucla).

Miss Crespin (1956) has shown from a study of the foraminifera that the Nullabor Limestone at Eucla can be divided further into an upper formation of hard foraminiferal crystalline limestone and a lower formation of hard bryozoan limestone. The upper is over 40 feet thick and "contains an assemblage of foraminifera which is found in the Trealla Limestone of the Carnarvon Basin and is typical of "f_1"-"f_2" stage in Indo-Pacific Tertiary stratigraphy. It is equivalent to the upper part of the Lower Miocene." The lower hard bryozoan limestone is about 40 feet thick and "the lithology is characteristic of that found in the Giralia Calcarenite in the Carnarvon Basin. There is little doubt that these rocks are upper Eocene in age." Foraminifera from specimens presumably of the Wilson Bluff Limestone were also shown to indicate upper Eocene age.

Nature and Significance of Jointing

The jointing which forms the subject of this paper has been observed at only one locality, in a cave which has been called the Madura South Cave. This cave is about six miles south of the Hampton Escarpment at Madura and is on the Eyre Coastal Plain. It is one of the shallower caves of the basin having a maximum depth of about 65 ft. below the plain level and not reaching the water table. Since only very small areas of the Eucla Basin have been subject to even preliminary geological investigation it cannot be definitely stated that similar jointing is not exposed elsewhere, but in the deep caves of the Nullarbor Plain, of which Murra-el-ellivan, Cocklebiddy, and Abracurrie were visited, no such jointing was noticed. It is probable, however, that widely-spaced joints and lines of weakness occur over large areas.

The jointing in the Madura South Cave is made evident by erosion along the joint planes. On the inside of the cave this tends to produce a series of elongate chimneys and on the outside wide cracks or, less commonly, solution pipes. Where the two join there is in one instance considerable widening to produce a small intermediate cave. Few of the joints are perfectly planar, most curving to give gentle horizontal rolls, but the average dip is always vertical. Since the straight passages of the cave are obviously parallel to joint directions, and in several instances actually follow joints, their directions are included in Table I and were used in computing the mean directions of the joint sets.

The pattern developed (Fig. 1) consists of four joint sets which are interpreted as two conjugate shears bisected at right agles by one compression and one tension set. This pattern is that usually developed in homogeneous rocks under stress. There is some controversy over the interpretation of the theoretical pattern but here, where flow is not believed to have been important and where jointing took place at shallow

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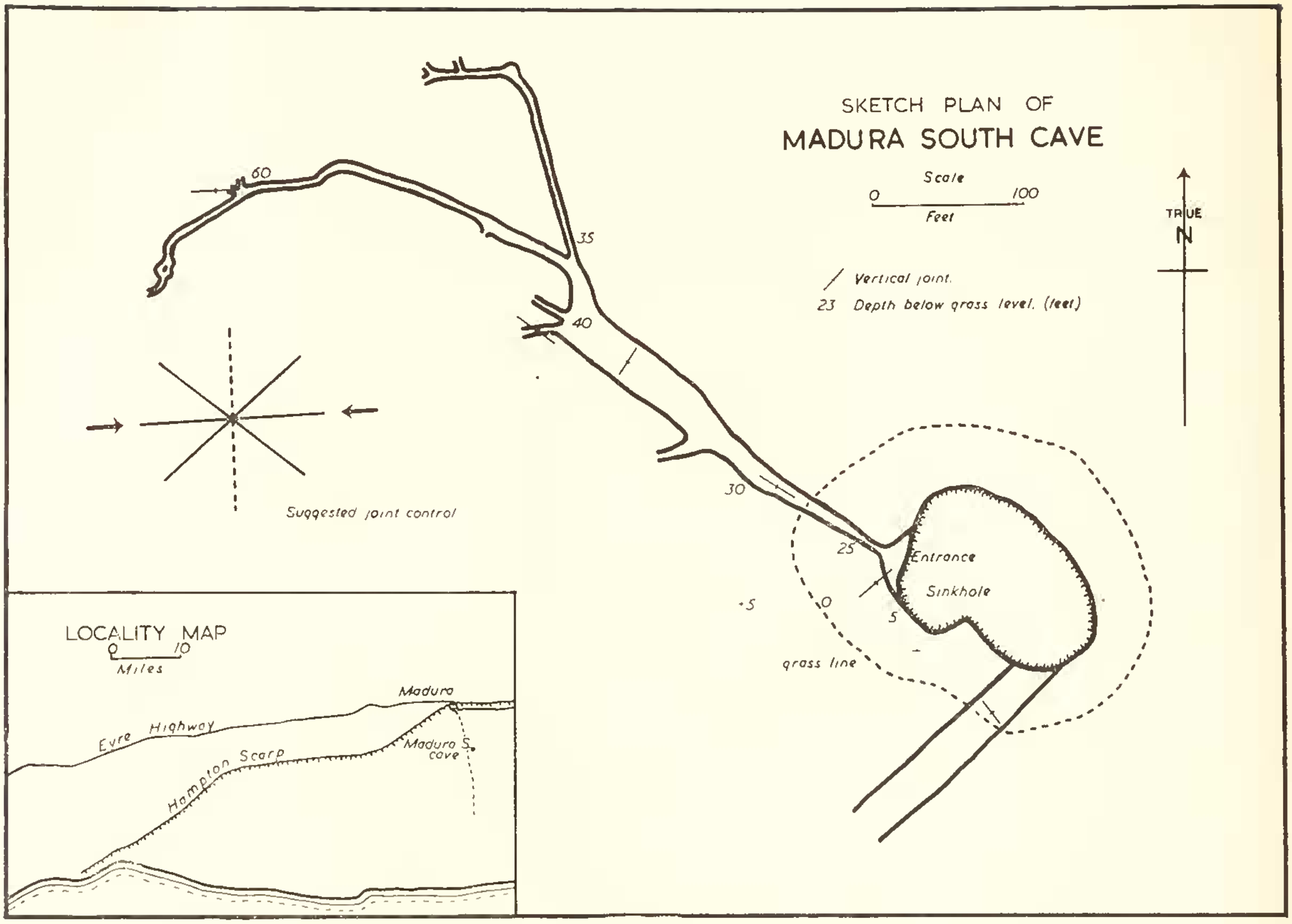

Fig. 1

depths there is little doubt that the stress hypothesis applies and that the acute angle between the conjugate shears is bisected by the axis of maximum stress. As may be seen from Table I there are certain deviations from the ideal; thus the compression set is represented only by a cavern direction and varies by about 11° from the ideal and the shear sets seem to be split into two separate pairs. The latter is easily explicable as due to a change in stress, and the former variation might be expected for any single joint. Not much importance can be attached to such aberrations, the surprising feature is not that they exist but that they are so slight. The two conjugate shears are particularly well developed with their acute angles to the east and west. From this it is inferred that at the time of jointing the axis of intermediate stress was vertical and that of minimum stress, N.-S. It is possibly this joint system which controlled the orientation of the elongate dark patches on the ground (trending N.E.-S.W., 40 miles south of Forrest and E.N.E.-W.S.W. and N.W.-S.E. concurrently 36 miles S.E. of Cook) seen from the air by Woolnough (1933). No indication of the loading which applied that stress can be obtained from the jointing alone without reference to the regional history.

TABLE I.

Strikes of joints and passage directions in Madura South Cave

Strikes		Mean of strike directions	Suggested type of joint
Joints	Main passage directions		
33°	51°	48 ± 7*	Shear
49°	49°		
87°	....	87°	Tension
126°	119°	128 ± 7	Shear
142° ±	131°		
	165°	165	Compression

* Mean deviation.

It is obvious from the considerable thickness of moderately shallow water sediments preserved in the Eucla Basin (at least 2000 ft.) that the area has had a fairly continuous negative isostatic tendency since the Cretaceous. It is crossed by three south-facing escarpments, the Hampton Escarpment, the Bunda or Great Bight Escarpment which faces the sea and is almost certainly the continuation of the Hampton Escarpment, and the submarine escarpment in the Great Australian Bight. Woolnough (1933) and Gentilli and Fairbridge (1951) suggest that each of these is a fault scarp whereas Maitland (1919) and Singleton (1954) consider both the Bunda and Hampton Escarpments to be the result of marine erosion. The evidence for the two southern escarpments being fault scarps is mainly physiographic and will not be considered here. The evidence for, the existence of the Hampton Fault is both physiographic and stratigraphic.

The linear tendency of the scarp face, the plains of similar rocks at levels differing by about 300 ft. on either side of the scarp and the typical fault scarp physiography all suggest faulting.

Bore logs from Transcontinental Railway bore No. 3, 337 miles, 61 chains (near Loongana), Madura No. 2 (30 miles north of Madura) and Madura No. 1 (30 chains south of the scarp at Madura) suggest a drop in succession of over 300 feet (Fig. 2). The marker horizons are the base of the Nullarbor Limestone and the top of an unnamed hard limestone member in the Wilson Bluff Limestone. The Madura No. 2 bore is not deep enough to cut the second marker horizon but as a hand-boring plant was used it is probable that the bore stopped at the hard limestone member, which is represented in both the other bores. A second bore near Loongana using a hand-boring plant also stopped at this hard member.

The log of the Transcontinental Railway bore No. 3, 337 miles 61 chains (near Loongana) has not previously been published in full and is quoted in Table II for convenience (Forman, 1943).

Taken together the physiographic and stratigraphic evidence leave little doubt that the Hampton Scarp represents the surface cxpression of a young fault with a downthrow to the south of over 300 ft.

It is important to know whether the postulated fault predates or postdates the jointing. As may be seen from Fig. 1 the lineaments of the scarp, taken from the Australian Aeronautical Map, June 1944, closely parallel the joint directions and strongly suggest that the faulting postdates joint formation.

The lack of dissection of the plateau and the fact that thick post-Miocene sediments have not been recorded suggest that the present surface was probably never heavily loaded by superimposed sediments. Under such conditions compressional loading, of magnitude suitable to form joints, would have produced a horizontal axis of intermediate strain, the direction of easiest relief being upwards. Since the jointing indicates the presence of a vertical axis of intermediate strain there remain the possibilities of either shearing or tensional loading. The possibility of shearing loading cannot be entirely ruled out but it was obviously not in operation at the time of formation of the Hampton Fault, unless the angular outcrop was caused by secondary faulting, and since its direction would have to be either N.E.-S.W. or N.W.-S.E. it is difficult to see any feature with which it could be associated.

Tensional loading seems the most probable explanation. Such tension could be produced in three ways:—regional tension, tension due to drag on faults, or tension on an upper axis of an anticlinal warp. Regional tension would not be expected to produce close jointing so near to the surface. There is no evidence of faulting near the cave except the Hampton Fault which postdates the jointing. We know that the basin has had a tendency to downwarp to the south so it seems probable that local warping also

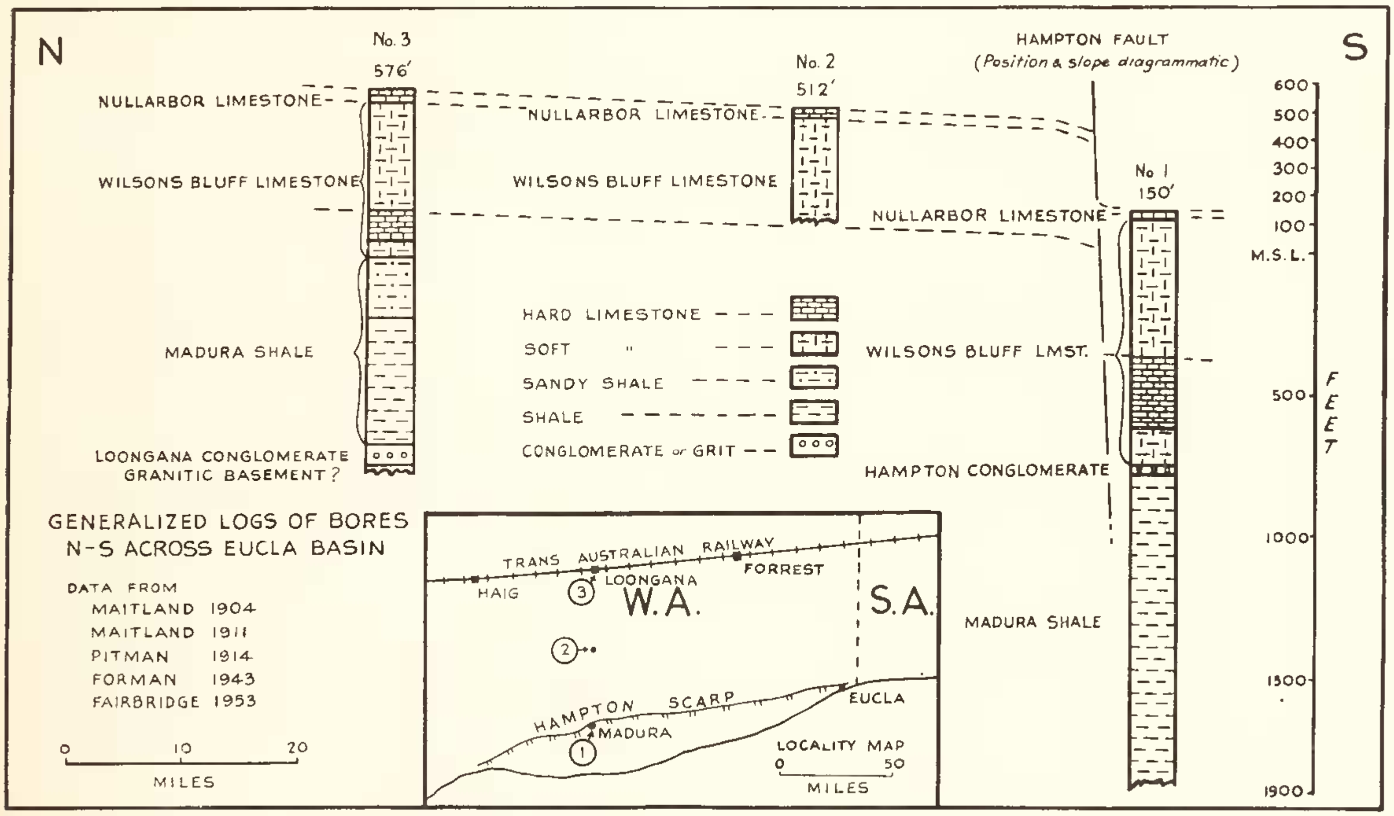

Fig. 2

TABLE II.

Transcontinental Railway bore No. 3 at 337 miles 61 chains

R.L. of surface 576 ft. above sea level.

Depth below surface in ft.	Description of strata	Remarks
0— 3	Soil	Boring commenced 12/8/1909
3— 50	Hard limestone with blow holes	
50— 65	Soft limestone	
65— 67	Hard limestone	
67— 405	Soft limestone	Rest level of local water 295 ft.
405— 430	Soft limestone with hard bands	Water level (artesian) 420 ft.
430— 530	Hard limestone with flints	
530— 630	Soft limestone with flints	
630— 813	Soft green sandy shale	
813— 816	Hard bands of shale	
816— 857	Sandy shale with small hard bands	
857— 860	Hard bands of shale	
860— 890	Soft sandy shale	
890— 892	Hard bands of shale	
892— 905	Soft sandy shale	
905— 910	Hard bands of shale	
910—1270	Soft puggy shale	
1270—1344	Fine and coarse sand with hard bands of granite boulders	Artesian water struck in this stratum stands in bore at 420 ft. from surface.
1344—1370	Decomposed granite	
1370—1372	Hard granite	

took place. That such warping should predate any important faulting also seems very probable and suggests that this was the mechanism that produced the jointing.

It may therefore be concluded that the jointing is due to tensional forces on the upper axis of an anticlinal warp associated with sinking to the south which was followed by the production of a normal fault, the Hampton Fault.

Acknowledgments

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